Exhibit A

PTO/SB/16 (6-95)
Approved for use through 04/11/98. OMB 0651-0037
Patent and Trademark Office, U.S. DEPARTMENT OF COMMERCE

A PROV

PROVISIONAL APPLICATION COVER SHEET

This is a request for filing a PROVISIONAL APPLICATION under 37 CFR § 1.53(b)(2).

jc408 U.S. PTO 05/18/99

jc542 U.S. PTO 60/134666 05/18/99

Docket Number	1736/00008	Type a plus sign (+) inside this box	+

INVENTOR(s)/APPLICANT(s)

LAST NAME	FIRST NAME	MIDDLE INITIAL	RESIDENCE (CITY AND EITHER STATE OR FOREIGN COUNTRY)
Ausubel	Lawrence	M.	Washington, D.C.

TITLE OF INVENTION (280 characters max)

System and Method for an Efficient Dynamic Auction for Multiple Types of Multiple Objects

CORRESPONDENCE ADDRESS

Stanley B. Green
Pollock, Vande Sande & Amernick
P.O. Box 19088
Washington

STATE	D.C.	ZIP CODE	20036	COUNTRY	U.S.A.

ENCLOSED APPLICATION PARTS *(check all that apply)*

[x]	Specification	*Number of Pages*	[9]	[]	Small Entity Statement
[x]	Drawing(s)	*Number of Sheets*	[5]	[]	Other (specify) ______

METHOD OF PAYMENT *(check one)*

[x]	A check or money order is enclosed to cover the Provisional filing fees	PROVISIONAL FILING FEE AMOUNT ($)	$ 150
[]	The Commissioner is hereby authorized to charge the filing fees and credit Deposit Account Number: 22-0185.		

The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.

[x] No.
[] Yes, the name of the U S. Government agency and the Government contract number are. ______

Respectfully submitted,

SIGNATURE Stanley B. Green

Date May 18, 1999

TYPED or PRINTED NAME Stanley B. Green

REGISTRATION NO. *(if appropriate)* ~~24,852~~ 24,351

[] Additional inventors are being named on separately numbered sheets attached hereto

PROVISIONAL APPLICATION FILING ONLY

60134666 . 051899

BEST AVAILABLE COPY

SYSTEM AND METHOD FOR AN EFFICIENT DYNAMIC AUCTION FOR MULTIPLE TYPES OF MULTIPLE OBJECTS

Field of the Invention

The present invention relates to improving computer-implemented auctions and, more particularly, to computer implementation of an efficient dynamic auction for multiple types of multiple objects.

Background of the Invention

Auction formats in the art tend generally to be of the sealed-bid or ascending-bid variety. In the standard sealed-bid auction, bidders -- in one single bidding round -- simultaneously and independently submit bids to the auctioneer, who then determines the auction outcome. In the standard ascending-bid auction, bidders -- in a dynamic bidding process -- submit bids in real time until no more bids are forthcoming. An ascending-bid format offers the advantage that there is feedback between participants' bids: each bidder is able to infer other bidders' information about the value of the object(s) as the auction progresses and incorporate this information into his subsequent bids. This feedback tends to result in more efficient auction outcomes as well as more aggressive bidding, resulting in higher expected revenues for the seller.

However, known ascending-bid formats -- such as the design used by the Federal Communication Commission for auctioning radio communications spectrum -- have the disadvantage that they do not generally lead to outcomes which are efficient in the sense of assigning objects to the bidders who value them the most. My prior application S.N. 08/582,901 provides a system and method for a dynamic auction, which may achieve efficiency for situations involving multiple identical objects. The current invention is an system and method for a dynamic auction which may achieve efficiency for analogous situations involving multiple types of multiple objects.

Summary of the Invention

The present invention is a system and method for conducting an auction in which the price paid by bidders is independent of their own bids, in which participants are provided with information concerning their competitors' bids as the auction progresses, and in which the confidentiality of high values is maintained. This provides the advantage of improving the economic efficiency of the auction design over the prior art.

The present invention comprises a bidding information processor (BIP) and a plurality of bid entry terminals (BET's) communicatively coupled to the bidding information processor. Bidders at the bid entry terminals enter bids in multiple rounds, and may observed displayed auction information. The bidding information processor and the bid entry terminals communicate and process information in order to conduct an auction.

Suppose that m ($m \geq 1$) types of objects are being auctioned, and a plurality of identical units (or close substitutes) of each type are being auctioned. An auction in accordance with the present invention proceeds as follows. First, the auctioneer (i.e., the bidding information processor) determines a starting price vector, $(P_1, \ldots ,P_m)$, and transmits it to bidders (i.e., bid entry terminals). Second, a bidder responds with a bid vector indicating the quantity of each respective type of object that the bidder wishes to transact at the current price vector. Let the bidders be superscripted by i, where $i = 1, \ldots , n$. The bid vector for bidder i is denoted by $(Q_1^i, \ldots ,Q_m^i)$. Also, let the quantities of the respective types of objects being auctioned be denoted by $(\bar{Q}_1, \ldots ,\bar{Q}_m)$. Typically, the aggregate quantity of each type of object desired by all the bidders (i.e., $\sum_i Q_k^i$) is greater than the quantity of each type of object being auctioned (i.e., $\bar{Q}_k$). In this event, the auctioneer still determines whether any of the objects should be assigned to any bidders in this round. This is done by determining for each bidder, separately, whether the sum of the quantities bid by all the other bidders for all m types of objects is less than the sum of the quantities of all m types of objects being auctioned. In other words, there is at least one object which is desired by only one bidder. In the event that the auctioneer determines a bidder who should be assigned objects, the auctioneer further determines which type(s) of objects should be

assigned to such bidder. This is done by determining for each type of object, separately, whether the sum of the quantities bid for this type of object by all the other bidders is less than the sum of the quantities being auctioned. In other words, there is at least one object of this type which is desired by only one bidder. Those objects, of those types, are then assigned to that bidder, obligating that bidder to transact them at the prices standing for those types of objects at that time. (If more than one possible assignment vector to that bidder is consistent with this rule, then the auctioneer is permitted to select his most-preferred assignment vector consistent with this rule.) If any objects remain unassigned, the auctioneer announces a new price vector and the auction continues.

Certain constraints are desirable in order for this auction to operate optimally and to reach an economically efficient outcome. One exemplary constraint is an activity rule which constrains a bidder not to increase his quantity, summed over the *m* types of objects, from one round to the next. Another exemplary constraint is a reduction rule which constrains a bidder not to decrease his quantity, for any single type of object, beyond the point where the sum of the quantities bid for this type of object by all bidders equals the sum of the quantities being auctioned. (If, in a given round, two or more bidders simultaneously attempt to decrease their quantities, for any single type of object, having the effect of reducing bids beyond the point where the sum of the quantities bid for this type of object by all bidders equals the sum of the quantities being auctioned, the auction procedure will resolve this discrepancy. For example, the auctioneer may honor these attempts to decrease in order of time priority, or may ration these simultaneous attempts to decrease in proportion to the attempted reductions.)

While an auction following these rules could be conducted manually, computerized conduct of the auction allows the auction to be conducted with all bidding information taken into account, while controlling the degree to which the information itself is disclosed to the participants. Computerized conduct of the auction also allows the auction to be conducted swiftly and reliably, even if bidders are not located on-site. The amount of information which is transmitted to the bid entry terminals and/or actually displayed to the bidders may be carefully controlled. In one embodiment, all bidding information is displayed to the bidders. In another embodiment, no bidding information is displayed to the bidders; only the

results of the auction are displayed. A number of intermediate embodiments are also possible, in which some but not all bidding information is displayed to the bidders. For example, in one preferred embodiment, the auctioneer disclose only the aggregate quantity bid for each type of object in each round, as opposed to disclosing each individual bid.

My prior application S.N. 08/582,901 treated auctions for multiple, identical objects and close substitutes. The earlier application's alternative auction -- which may be viewed as a special case of the current auction design -- exploited features of the homogeneous-good environment to construct an eminently-simple dynamic procedure. Unfortunately, the case of multiple types of objects does not lend itself to quite as simple a procedure. My second prior application S.N. 08/775,880 described other auction designs for multiple, dissimilar objects. However, the current auction design appears likely in practice to be simpler and to run more swiftly, as well as placing lower computational demands on bidders.

The present invention is useful for conducting auctions involving objects offered for sale by the bidders, as well as objects offered for sale to the bidders. Although terms such as "vector of quantities demanded" (by a bidder) and "demand curve" (of a bidder) are used to describe the present invention, the terms "vector of quantities offered" (by a bidder) and "supply curve" (of a bidder) are equally applicable. In some cases, this is made explicit by the use of both terms, or by the use of the terms "vector of quantities transacted" (by a bidder) and "transaction curve" (of a bidder). The term "quantities transacted" includes both "quantities demanded" and "quantities offered". The term "bid" includes both offers to sell and offers to buy. The term "transaction curve" includes both "demand curve" and "supply curve". Moreover, any references to "quantities being offered" includes both "quantities being sold" by the auctioneer, in the case this is an auction for selling objects, as well as "quantities being bought or procured" by the auctioneer, in the case this is an auction for buying objects or procuring objects.

Throughout this document, the terms "objects", "items", and "units" are used essentially interchangeably. The inventive system may be used both for tangible objects, such as real or personal property, and intangible objects, such as telecommunications licenses or electric power. The inventive system may be used in auctions where the auctioneer is a seller, buyer or broker, the bidders are buyers, sellers or brokers, and for auction-like

activities which cannot be interpreted as selling or buying. The inventive system may be used for items including, but not restricted to, the following: public-sector bonds, bills, notes, stocks, and other securities or derivatives; private-sector bonds, bills, notes, stocks, and other securities or derivatives; communication licenses and spectrum rights; electric power and other commodity items; rights for terminal capacities in gas pipeline systems; airport landing rights; emission allowances and pollution permits; and other objects, items or property, tangible or intangible. It may be used in initial public offerings, secondary offerings, and in secondary or resale markets.

The communication system used can be any system capable of providing the necessary communication and includes for example a local or wide area network such as for example ethernet, token ring, or alternatively a telephone system, either private or public, the Internet, the Worldwide Web or the information superhighway.

Detailed Description of Preferred Embodiments

The drawings of Figures 1-4 of my prior application S.N. 08/582,901 and of Figures 1-12 of my second prior application S.N. 08/775,880, and the associated text, provide a general superstructure for the present auction method and system, especially as it relates to the computer implementation thereof. Moreover, the terminology set in the previous applications will be relied upon as needed. The following description will detail the flow of the novel features of the preferred embodiments of the present method and system for an efficient dynamic auction for multiple types of multiple objects.

Figure 1 is a flow diagram of an auction process in accordance with one embodiment of the present invention. The process starts with step 102, in which memory locations are initialized. In step 102, the appropriate memory locations are initialized with information such as the number of types of objects for auction, the quantity of each type of object for auction, and the initial price vector. In step 104, the bidding information processor transmits auction information, including the starting price vector $(P_1, \ldots, P_m)$, and transmits it to bid entry terminals. In step 106, bid entry terminals receive auction information from the bidding information processor and display it to bidders. In step 108, bid entry terminals

receive bids $(Q_1^i, \dots, Q_m^i)$ from bidders and transmit them to the bidding information processor. In step 110, the bidding information processor receives the bids transmitted from bid entry terminals and transmits confirmation messages. In step 112, the bidding information processor closes the bidding for the current round and processes bids received from bid entry terminals. This process is shown in more detail in Figure 3. In step 114, the bidding information processor assigns objects, if any, at the current prices. This process is shown in more detail in Figures 2a, 2b and 2c. In step 116, the bidding information processor determines if any objects remain unassigned. If so, the process goes to step 118 in which the bidding information processor increments the current price vector and generates the bidding history and any auction announcements and messages. One exemplary rule for incrementing the price is that, for every $k = 1, \dots, m$, the price P_k of objects of type k is raised by $c\,[(\sum_i Q_k^{i,t}) - \overline{Q_k^t}\,]$, where c is a positive constant (i.e., the price for each type is increased in direct proportion to the excess demand for that type). The process then loops to step 104. If no objects remain unassigned, then the process ends.

Figure 2a is a flow diagram of a subprocess of step 114. It begins with step 114-1, in which the bidding information processor sums the quantities demanded by all the bidders and for all the types of objects; also sums the quantities remaining unassigned of all the types of objects; and computes the difference between the two sums. In step 114-2, the bidding information processor determines whether the difference between these two sums is (strictly) greater than zero. If the difference between the two sums is (strictly) greater than zero, the process continues with step 114-3, in which the bidding information processor considers each bidder separately and determines an assignment of objects at the current prices. This step is shown in more detail in Figure 2b. The process then goes to step 116 of Figure 1. If the difference between the two sums is not (strictly) greater than zero, the process continues with step 114-4, in which each bidder is assigned the quantity bid for each type of object at the current price, and since no objects remain unassigned, the auction ends after proceeding to step 116 of Figure 1.

Figure 2b is a flow diagram of a subprocess of step 114-3. It begins with step 114-3-1, in which a bidder which has not yet been considered is selected. In step 114-3-2, for the bidder currently being considered, the bidding information processor sums the

quantities remaining unassigned of all the types of objects; also it sums the quantities demanded by all the bidders other than the current bidder and for all the types of objects; and it computes the difference between the two sums. The difference is denoted $\hat{Q}^i$. In step 114-3-3, the bidding information processor determines whether $\hat{Q}^i$ is (strictly) greater than zero. If $\hat{Q}^i$ is not (strictly) greater than zero, no objects are assigned to the current bidder, and the process proceeds directly to step 114-3-6. If $\hat{Q}^i$ is (strictly) greater than zero, the process continues with step 114-3-4, in which the bidding information processor considers each type of object separately and determines an assignment of objects at the current prices. This step is shown in more detail in Figure 2c. In step 114-3-5, the bidding information processor subtracts the assigned quantities from the bids of the current bidder and from the quantities for auction. In step 114-3-6, it is determined whether all bidders have been considered. If not, the process loops back to step 114-3-1. If all bidders have been considered, the process goes to step 116 of Figure 1.

Figure 2c is a flow diagram of a subprocess of step 114-3-4. It begins with step 114-3-4-1, in which for every type $k = 1, \ldots, m$ of object, the bidding information processor sums the quantity demanded of type k by all the bidders other than the current bidder, and subtracts this from the quantity remaining unassigned of type k. The difference is denoted $\hat{Q}_k^i$. In step 114-3-4-2, the bidding information processor determines whether the sum of the $\hat{Q}_k^i$, summed over all types $k = 1, \ldots, m$ of objects, equals $\hat{Q}^i$. If the sum of the $\hat{Q}_k^i$ equals $\hat{Q}^i$, then the process continues with step 114-3-3. In step 114-3-3, $(\hat{Q}_1^i, \ldots, \hat{Q}_m^i)$ is determined to be the assignment to bidder i, and the process goes to step 114-3-5 of Figure 2b. If the sum of the $\hat{Q}_k^i$ does not equal $\hat{Q}^i$, then the process continues with step 114-3-4. In step 114-3-4, the bidding information processor determines the most-preferred assignment $(Q_1^{i*}, \ldots, Q_m^{i*})$ which satisfies the following constraints: $0 \leq Q_k^{i*} \leq \hat{Q}_k^i$ for every type $k = 1, \ldots, m$; and $\sum_k Q_k^{i*} = \hat{Q}^i$. One exemplary way of selecting the most-preferred assignment is to select the $(Q_1^{i*}, \ldots, Q_m^{i*})$ consistent with the constraints such that the difference between the expected final price vector and the current price vector, multiplied by $(Q_1^{i*}, \ldots, Q_m^{i*})$ as a dot product, is minimized. The determined $(Q_1^{i*}, \ldots, Q_m^{i*})$ is deemed to be the assignment to bidder i, and the process goes to step 114-3-5 of Figure 2b.

Figure 3 is a flow diagram of a subprocess of step 112. It begins with step 112-1, in which the bidding information processor considers a bidder who has submitted a bid which has not yet been considered. This bidder is denoted bidder i. One exemplary way of selecting which bidder to consider is to select the earliest-time-stamped bid which has not yet been considered. In step 112-2, the bidding information processor recalls from memory the most recent previously-processed bid by bidder i, the bidder currently being considered. The previously-processed bid is denoted $(Q_1^{i,t-1}, \ldots, Q_m^{i,t-1})$. In step 112-3, the bidding information processor determines whether bidder i's current bid satisfies the eligibility rule: $\sum_k Q_k^{i,t} \leq \sum_k Q_k^{i,t-1}$. If bidder i's current bid satisfies the eligibility rule, then the process skips to step 112-5. If bidder i's current bid does not satisfy the eligibility rule, the process continues with step 112-4, in which the bidding information processor adjusts bidder i's bid so as to satisfy the eligibility rule. One exemplary way of doing this is to insert bidder i's most recent previously-processed bid, $(Q_1^{i,t-1}, \ldots, Q_m^{i,t-1})$, as bidder i's current bid. In step 112-5, the bidding information processor determines whether bidder i's current bid satisfies the additional constraints: $\sum_i Q_k^i \geq \overline{Q}_k$, for all types $k = 1, \ldots, m$. If bidder i's current bid satisfies these additional constraints, then the process skips to step 112-7. If bidder i's current bid does not satisfy these additional constraints, the process continues with step 112-6, in which the bidding information processor adjusts bidder i's bid so as to satisfy the additional constraints. One exemplary way of doing this is to insert bidder i's most recent previously-processed bid, $(Q_1^{i,t-1}, \ldots, Q_m^{i,t-1})$, as bidder i's current bid. A second exemplary way of doing this is to substitute Q_k^i with $\overline{Q}_k - \sum_{j \neq i} Q_k^j$ as bidder i's quantity for type k, for every $k = 1, \ldots, m$ violating the additional constraint, provided that this substitution does not lead the eligibility rule to be violated. In step 112-7, the bidding information processor determines whether all bidders who have submitted bids have yet been considered. If not, the process loops back to step 112-1. If all bidders have been considered, the process goes to step 114 of Figure 1.

Another embodiment of the inventive system is described by the same flow diagrams – except with Step 114-3-4-4 deferred until the end of the auction. In that event, the

auctioneer is allowed to wait until the conclusion of the auction to determine which objects were assigned at which prices in the course of the auction.

Another embodiment of the inventive system is described by the same flow diagrams – except with Step 114-3 (and hence Figures 2b and 2c) deleted. In that event, the auction still proceeds with multiple ascending clocks, but now objects are not assigned in intermediate rounds, and so every object of a given type is assigned at the same price.

Figure 1

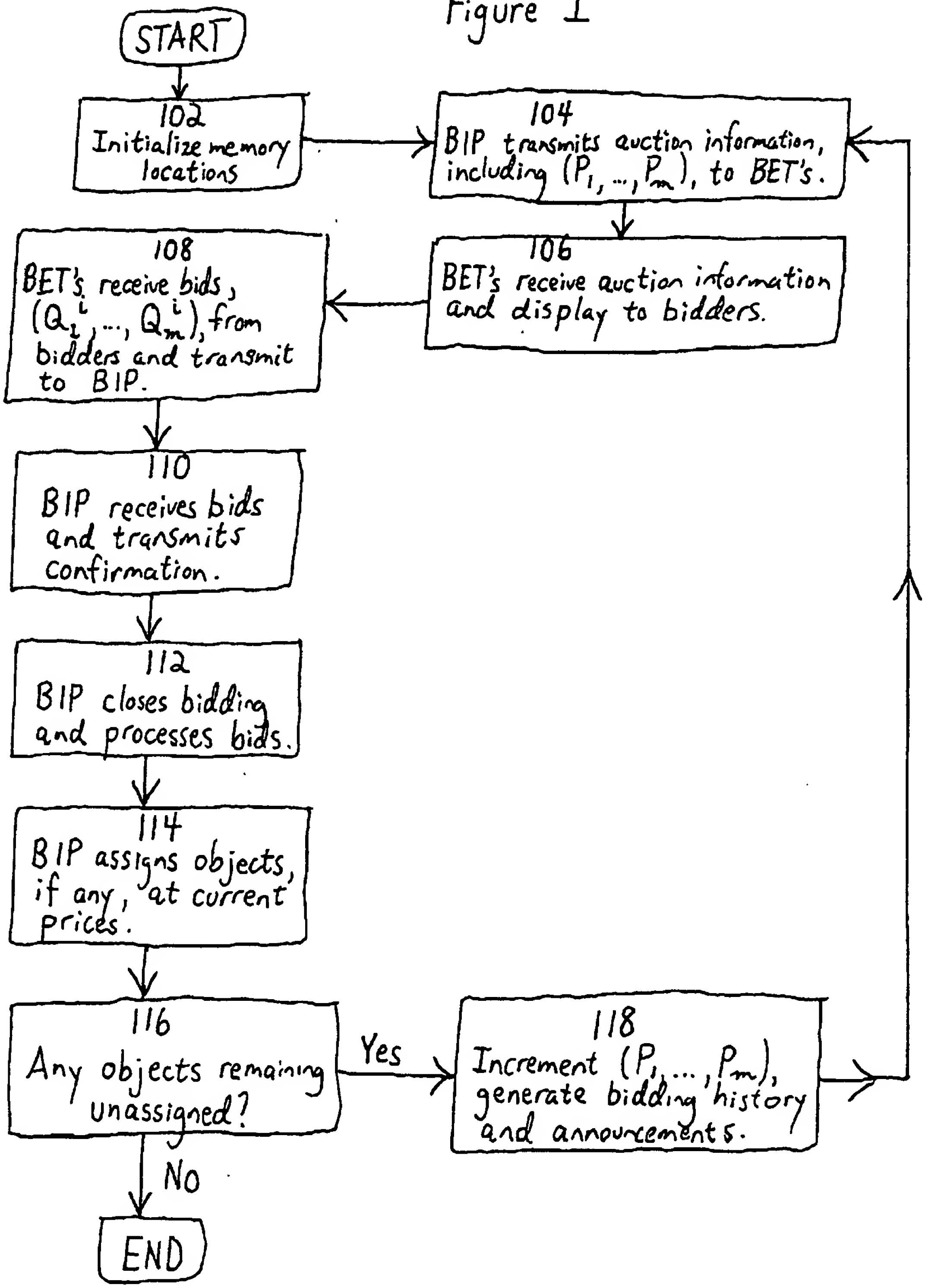
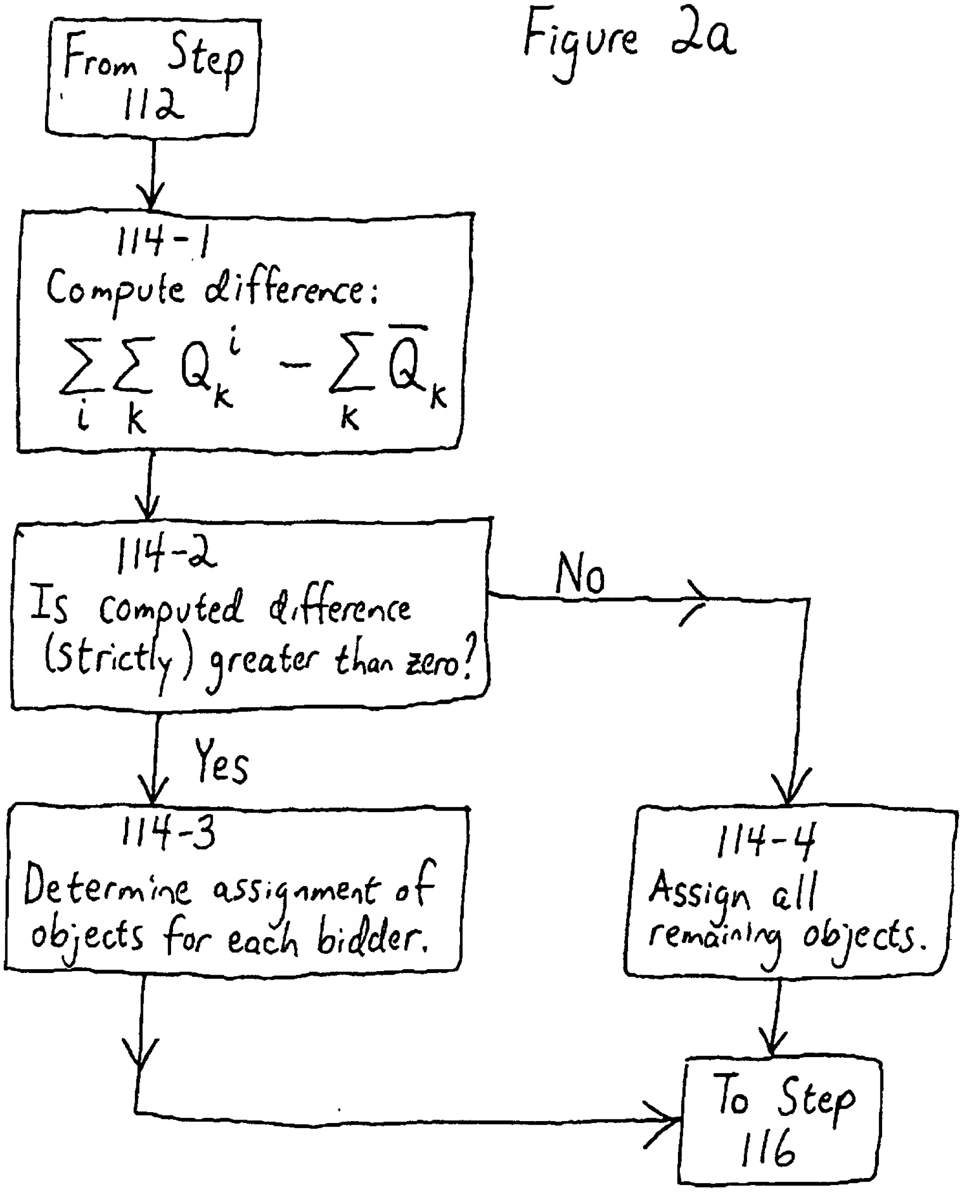
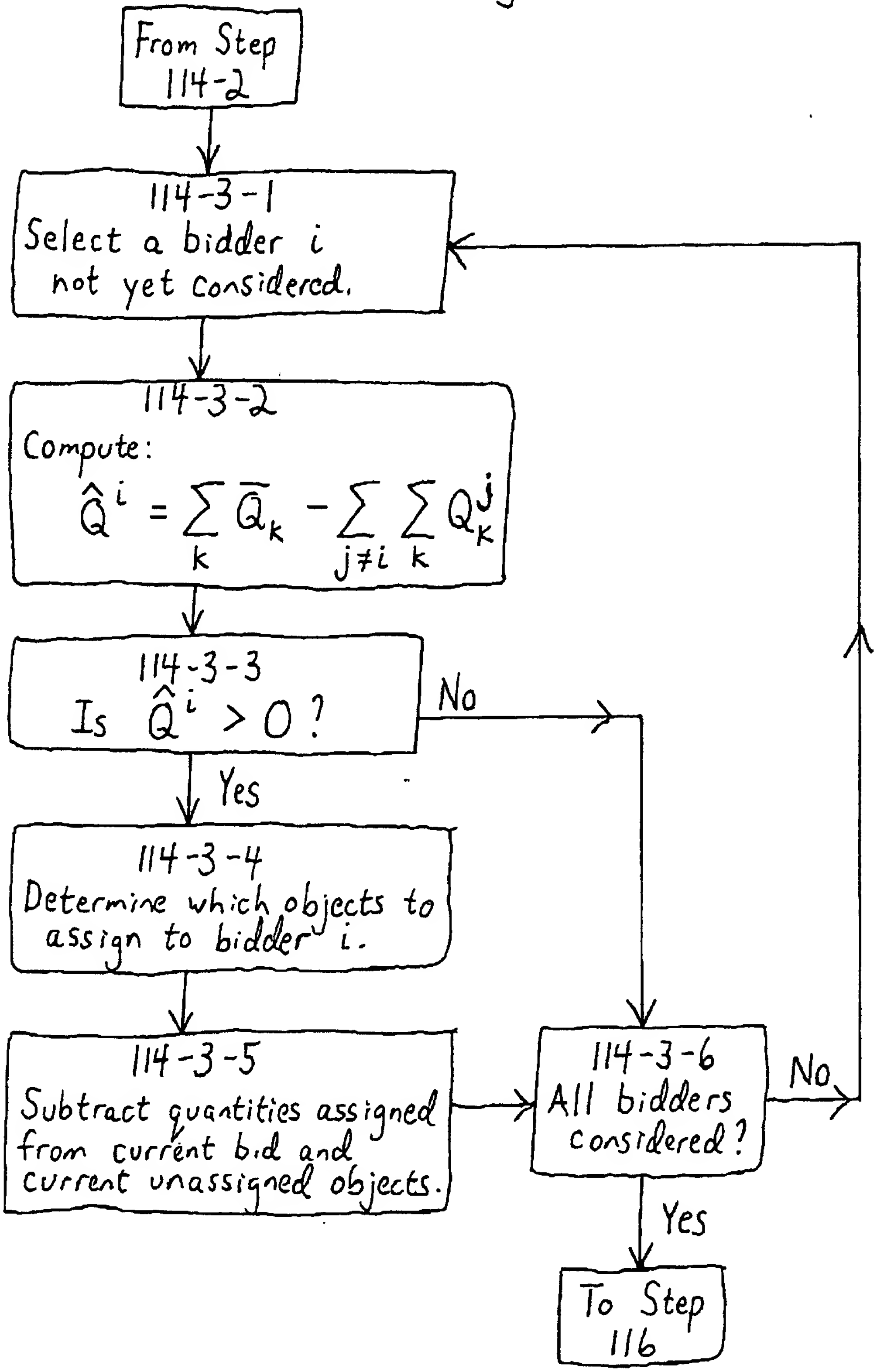

START
102 Initialize memory locations
104 BIP transmits auction information, including (P1, ..., Pm), to BET's.
106 BET's receive auction information and display to bidders.
108 BET's receive bids, (Q1i, ..., Qmi), from bidders and transmit to BIP.
110 BIP receives bids and transmits confirmation.
112 BIP closes bidding and processes bids.
114 BIP assigns objects, if any, at current prices.
116 Any objects remaining unassigned?
Yes
118 Increment (P1, ..., Pm), generate bidding history and announcements.
No
END

Figure 2a



From Step 112
114-1
Compute difference:
$\sum_i \sum_k Q_k^i - \sum_k \bar{Q}_k$
114-2
Is computed difference (strictly) greater than zero?
No
Yes
114-3
Determine assignment of objects for each bidder.
114-4
Assign all remaining objects.
To Step 116

Figure 2b



From Step 114-2
114-3-1
Select a bidder i not yet considered.
114-3-2
Compute:
$$\hat{Q}^i = \sum_k \bar{Q}_k - \sum_{j \neq i} \sum_k Q_k^j$$
114-3-3
Is $\hat{Q}^i > 0$?
No
Yes
114-3-4
Determine which objects to assign to bidder i.
114-3-5
Subtract quantities assigned from current bid and current unassigned objects.
114-3-6
All bidders considered?
No
Yes
To Step 116

Figure 2c

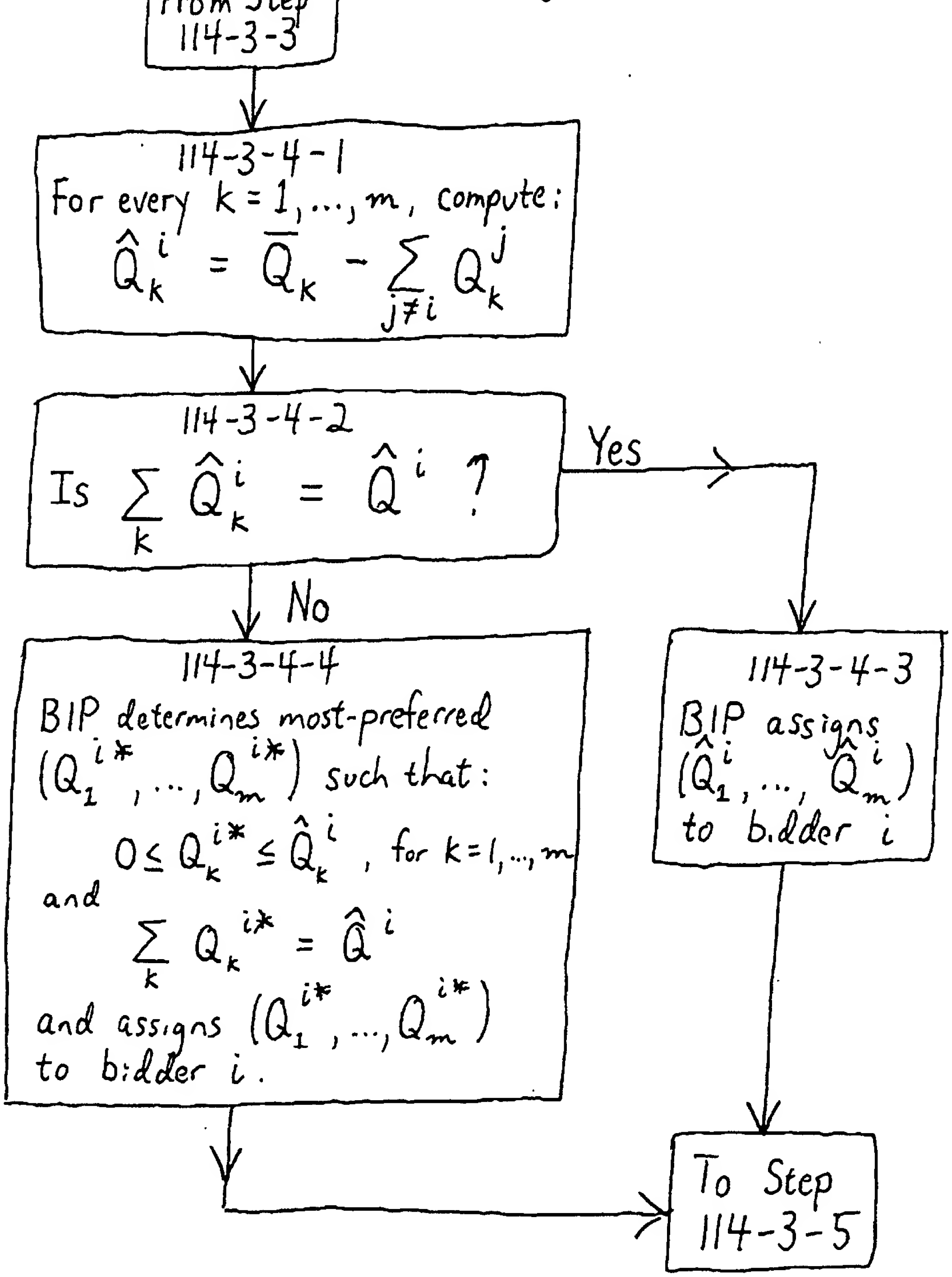
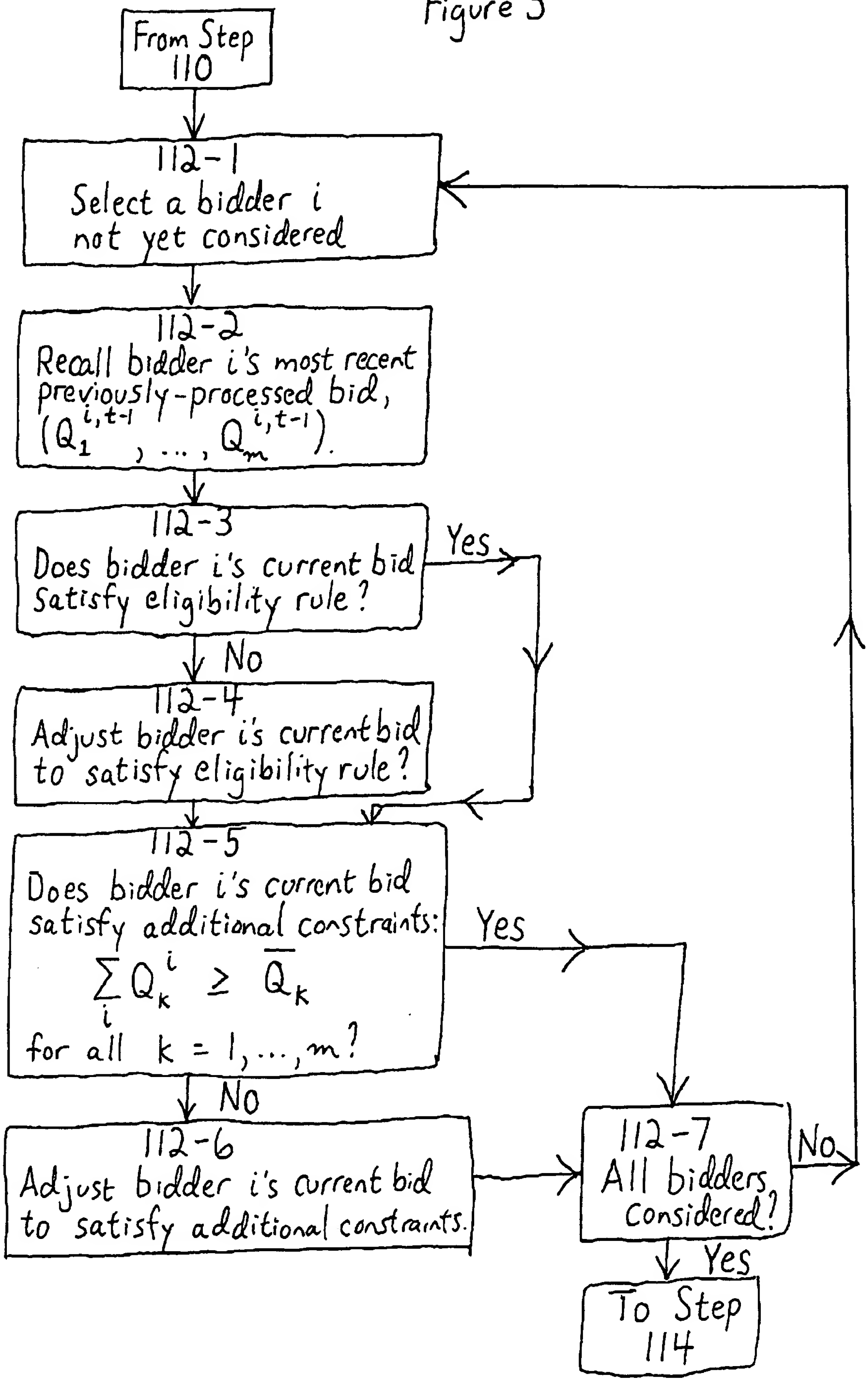

From Step 114-3-3
114-3-4-1
For every $k = 1, \ldots, m$, compute:
$\hat{Q}_k^i = \bar{Q}_k - \sum_{j \neq i} Q_k^j$
114-3-4-2
Is $\sum_k \hat{Q}_k^i = \hat{Q}^i$?
Yes
No
114-3-4-4
BIP determines most-preferred $(Q_1^{i*}, \ldots, Q_m^{i*})$ such that:
$0 \leq Q_k^{i*} \leq \hat{Q}_k^i$, for $k = 1, \ldots, m$
and
$\sum_k Q_k^{i*} = \hat{Q}^i$
and assigns $(Q_1^{i*}, \ldots, Q_m^{i*})$ to bidder i.
114-3-4-3
BIP assigns $(\hat{Q}_1^i, \ldots, \hat{Q}_m^i)$ to bidder i
To Step 114-3-5

Figure 3



From Step 110
112-1
Select a bidder i not yet considered
112-2
Recall bidder i's most recent previously-processed bid, $(Q_1^{i,t-1}, \ldots, Q_m^{i,t-1})$.
112-3
Does bidder i's current bid satisfy eligibility rule?
Yes
No
112-4
Adjust bidder i's current bid to satisfy eligibility rule?
112-5
Does bidder i's current bid satisfy additional constraints:
$\sum_i Q_k^i \geq \overline{Q}_k$
for all $k = 1, \ldots, m$?
Yes
No
112-6
Adjust bidder i's current bid to satisfy additional constraints.
112-7
All bidders considered?
No
Yes
To Step 114